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(71) Applicant: **Visteon Global Technologies, Inc.**
Dearborn, Michigan 48126-2490 (US)

(72) Inventors:
- **Kahlon, Gurinder Singh**
  Canton, MI 48188 (US)
- **Liu, Ning**
  3003 Novi, MI 48375 (US)
- **Mohan, Robert Joseph**
  Canton, MI 48187 (US)

(74) Representative: **Copp, David Christopher et al**
Dummett Copp,
25 The Square,
Martlesham Heath
Ipswich, Suffolk IP5 3SL (GB)

(54) Method and apparatus for starting an engine using an engine torque matching starter

(57) A system 40 for starting an internal combustion engine 12 of an automotive vehicle 10 has a controller 54 coupled to a starter/alternator 42 that is used for initiating the rotation crankshaft 50 of the engine 12. The controller 54 controls the amount of torque provided by the starter/alternator 42. When the speed of the crankshaft and thus the torque of the crankshaft 50 is in a desired range, the engine is started. The torque of the starter/alternator 42 preferably matches the torque curve of the engine. The starter/alternator 42 may be used to increase the torque to provide an increased torque upon starting.

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Description

Technical Fi ld

[0001] The present invention relates generally to internal combustion engines for automotive vehicles, and more specifically, to an automotive vehicle having a starter/alternator coupled to the engine.

Background

[0002] Automotive vehicles with internal combustion engines are typically provided with both a starter motor and alternator. In recent years, a combined alternator and starter motor has been proposed. Such systems have a rotor mounted directly to the crankshaft of the engine and a stator sandwiched between the engine block and the bell housing of the transmission. During initial startup of the vehicle, the starter/alternator functions as a starter. While functioning as a starter, the starter/alternator provides a sufficient amount of starting torque to rotate the crankshaft of the engine before the cylinders are fired. After the engine is fired, an amount of engine torque is provided to the crankshaft from the combustion process in the cylinders. There is a finite amount of time in which both starting torque and engine torque act on the crankshaft. If the differential amount of torques is excessive, the engine may appear as rough running. If a significant torque differential is generated damage to engine components such as the crankshaft may occur.

[0003] After the engine is started, the starter/alternator is used as a generator to charge the electrical system of the vehicle.

[0004] In foreseeable automotive applications, the engine may be shut down during stops (e.g., red lights). When the accelerator is depressed the engine will resume firing. Thus, many startups would occur over the course of a trip. Acceleration in such systems is inherently low absent intervention since torque levels upon startup is low.

[0005] It would therefore be desirable to reduce the differential torque between the starter/alternator and that present at the crankshaft to reduce the amount of stress on the crankshaft during startup. It would also be desirable to provide a system whereby the engine torque may be increased at startup to provide the vehicle with immediate acceleration.

Summary of the Invention

[0006] It is therefore one object of the invention to reduce the amount of differential torque on the crankshaft of the engine during startup.

[0007] In one aspect of the invention, an internal combustion engine has a starter coupled to the crankshaft of the engine. The engine has a predetermined operating torque curve method of controlling the starting of the engine, said method comprising the steps of:

rotating the crankshaft of the engine with the starter;
increasing a torque of the starter to a predetermined torque; and
starting the engine when the predetermined torque of the starter reaches a desired torque.

[0008] In a further aspect of the invention, a system for an automotive vehicle is coupled to an internal combustion engine with a crankshaft and a torque curve. The system has a starter coupled to the crankshaft. A controller is coupled to the starter for initiating the rotation of the crankshaft to a predetermined torque corresponding to the torque curve. The controller controls the starting of the engine upon the starter reaching a predetermined torque and speed on the torque curve.

[0009] One advantage is that the present invention is suitable for starting the engine at a higher torque so that more rapid acceleration may be obtained.

[0010] Other objects and features of the present invention will become apparent when viewed in light of the detailed description of the preferred embodiment when taken in conjunction with the attached drawings and appended claims.

Brief Description Of The Drawings

[0011]

Figure 1 is a schematic view of an automotive vehicle having a starter/alternator system according to the present invention; and

Figure 2 is a plot of a torque curve for an internal combustion engine of an automotive vehicle.

Description of a Preferred Embodiment

[0012] Referring now to Figure 1, an automotive vehicle 10 is illustrated having an internal combustion engine 12 with cylinders 14 with pistons 16 located therein. Each cylinder 14 is coupled to a fuel pump 18 through fuel lines and a fuel injector (not shown) or other fuel delivery system. Each cylinder 14 also has a spark plug 20 or other ignition source coupled to a powertrain control unit. A powertrain control unit 22 controls the ignition timing and fuel pump operation 18 in a conventional manner subject to the improvements of the present invention.

[0013] Engine 12 is coupled to a transmission 26. Transmission 26 may be automatic or manual. Transmission 26 is coupled to a differential 28 to drive an axle 30 to provide power to wheels 32. Of course, the present invention is also applicable to four wheel drive systems in which all of the wheels 32 are driven. A starter/alternator system 40 that includes a starter/alternator 42 and its associated control electronics is coupled to engine

12. In the present invention, starter/alternator 42 is positioned between a housing 44 of transmission 26 and the engine 12. Starter/alternator 42 has a stator fixedly attached to bell housing 44 and a rotor 48 coupled to a crankshaft 50 of engine 12. A clutch 52 is used to engage and disengage engine 12 from transmission 26. As will be further described below, starter/alternator 42 is used as a starter during engine startup and as an alternator (generator) to supply power to recharge the batteries of the vehicle. Clutch 52 allows starter/alternator 42 to start the engine prior to engagement with the transmission 26.

[0014] Crankshaft 50 has a sensor coupled thereto to determine the relative speed of the crankshaft. The torque of the engine may be derived from the crankshaft speed. Those skilled in the art would recognize various methods for determining crankshaft speeds including monitoring signals of the ignition system.

[0015] Starter/alternator system 40 has a system controller 54 that is coupled to powertrain control unit 22 and to a power inverter 56. The power inverter 56 and system controller 54 may in practice be contained in a single package. The inverter 56 is used to convert DC power to AC power in the startup mode and AC power to DC power in power generation mode as will be further described below.

[0016] Power inverter 56 is coupled to an energy storage device 58 such as an ultra capacitor, a first DC to DC converter 60, and a second DC to DC converter 62. DC to DC converter 60 is coupled to a 36 volt battery 64. DC to DC converter 62 is coupled to a 12 volt battery 66. Of course, the actual battery voltage is dependent on the particular system to which it is attached.

[0017] Referring now to Figure 2, a torque curve 70 and a power curve 72 for an engine are illustrated. The engine operates at a predetermined torque based on the engine design for various engine speeds. The engine speed is commonly the speed of rotation of the crankshaft.

[0018] In certain operating conditions of a motor vehicle, it may be desirable to provide a greater amount of torque from engine upon startup. The present invention is particularly applicable to systems in which the engine is completely shut down when the vehicle is at rest, such as at a stop light. In such a system, upon immediate depression of the acceleration pedal the starter/alternator may be used to increase the amount of torque to help the vehicle accelerate more rapidly.

[0019] In operation, the starter/alternator 42 has a controllable torque. The crankshaft 50 of engine 12 is rotated to a predetermined speed and with a predetermined torque to substantially match the torque of the engine at startup. Thus, the inverter 56 of starter/alternator system 40 is capable of substantially matching the torque output curve of the engine.

[0020] The starting process of engine 12 is initiated by a key placed in the ignition position or the depression of the accelerator pedal (not shown). Thirty-six volt battery 64 provides electrical power for starter/alternator 42 that is stepped up to 300 volts by DC to DC converter 60. The 300 volts is used to charge energy storage 58. Inverter 56 converts the DC power to three-phase AC power. The AC power is supplied to the stator 46 of starter/alternator 42. The starter/alternator 42 rotates rotor 48 which in turn rotates crankshaft 50 of engine 12. During the startup process, the starter/alternator 42 has a predetermined torque that is controlled by system controller 54.

[0021] When the rotor of the starter/alternator and thus the engine crankshaft reaches a predetermined torque, the engine 12 is started by supplying fuel through fuel pump 16 and controlling the spark timing through spark plugs 20 through powertrain control unit 22. Thus, as the engine is started, the desired torque and speed of engine 12 may be matched. The speed of crankshaft 50 may be measured directly by using sensor 53 or indirectly through the ignition system. Thus, upon rotor 80 reaching a sufficient torque, the controller 54 triggers the starting of the combustion process in the engine.

[0022] Because the starter/alternator 42 has a torque that is controlled, the starter/alternator 42 may be used to assist the engine to attain a desired torque upon startup. By increasing torque, immediate acceleration of the vehicle is increased.

[0023] Once the crankshaft reaches the desired torque and the engine combustion process is initiated, the starter/alternator 42 is used in a generating mode. In the generating mode, the energy storage device 58, and batteries 64, 66 are monitored to determine whether they are fully charged. If the energy storage sources drop below a predetermined charge range, three-phase power from starter/alternator 42 is converted to 300 volts DC by power inverter 56. DC to DC converters 60, 62 are used to convert the 300 volts DC to 42 volts and 14 volts respectively. It should be noted that the ultra capacitors of energy storage 58 are charged directly by power converter 56.

[0024] While particular embodiments of the invention have been shown and described, numerous variations and alternate embodiments will occur to those skilled in the art. Accordingly, it is intended that the invention be limited only in terms of the appended claims.

Claims

1. A method of controlling the starting of an internal combustion engine having a starter coupled to the crankshaft of the engine, said engine having a predetermined torque curve, said method comprising the steps of:

   rotating the crankshaft of the engine with the starter;

   increasing a torque of the starter to a predeter-

mined torque; and
starting the engine when the predetermined torque of the starter reaches a desired torque.

2. A method as recited in claim 1 wherein the desired torque substantially corresponds to the torque curve of the engine.

3. A method as recited in claim 1 wherein the step of starting the engine comprises the step of operating the fuel pump; and providing fuel to cylinders of the engine.

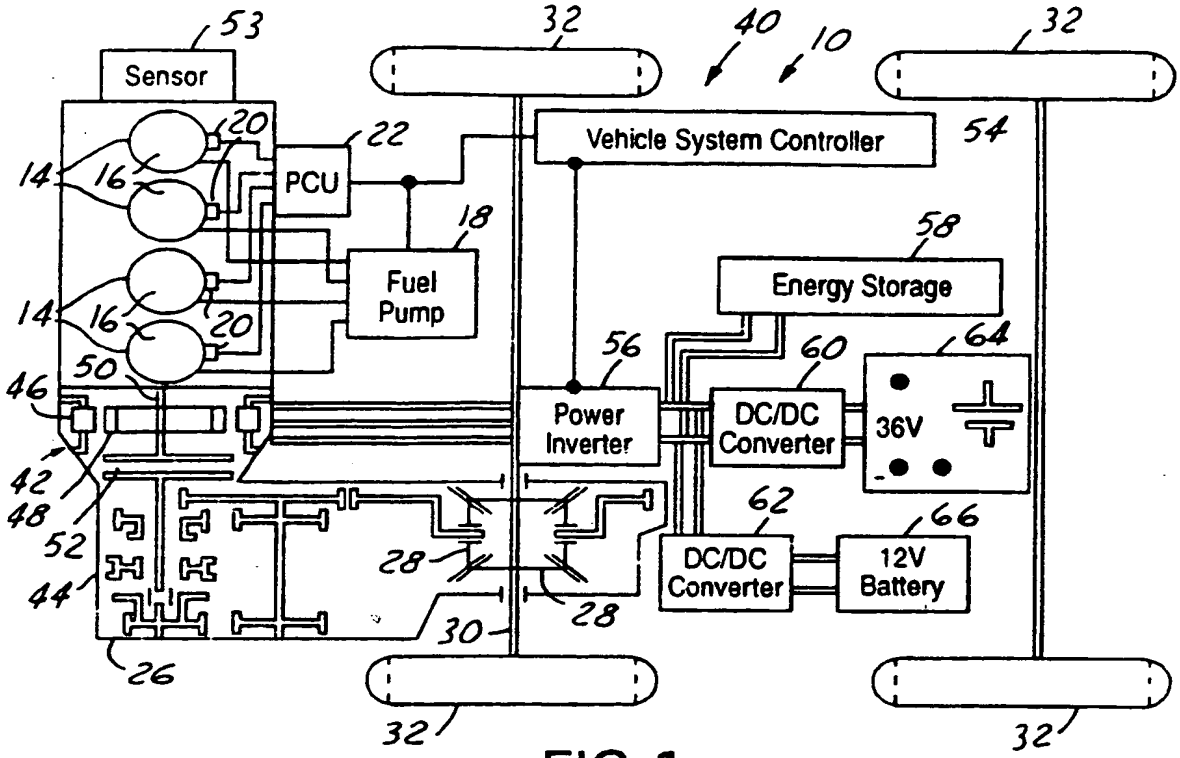
4. A method as recited in claim 1 wherein said step of starting includes starting the engine when a predetermined speed and said predetermined torque are reached.

5. A method of operating a vehicle with a starter/alternator coupled to an engine with a torque curve comprising the steps of:

initiating starting the engine;
rotating the crankshaft of the vehicle with the starter/alternator;
providing fuel and spark to the engine when the torque reaches the torque curve; and
assisting the engine with a starter/alternator to attain an increased torque output.

6. A method as recited in claim 5 wherein the step of providing fuel and spark comprises the step of operating the fuel pump; and providing fuel to cylinders of the engine.

7. A method as recited in claim 5 further comprising the step of providing fuel and spark to the engine when a predetermined speed is reached.


Sensor
PCU
Fuel Pump
Vehicle System Controller
Energy Storage
Power Inverter
DC/DC Converter
36V
DC/DC Converter
12V Battery
53
32
40
10
54
58
56
60
64
62
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20
22
18
14
16
50
46
42
48
52
44
28
30
26

FIG. 1

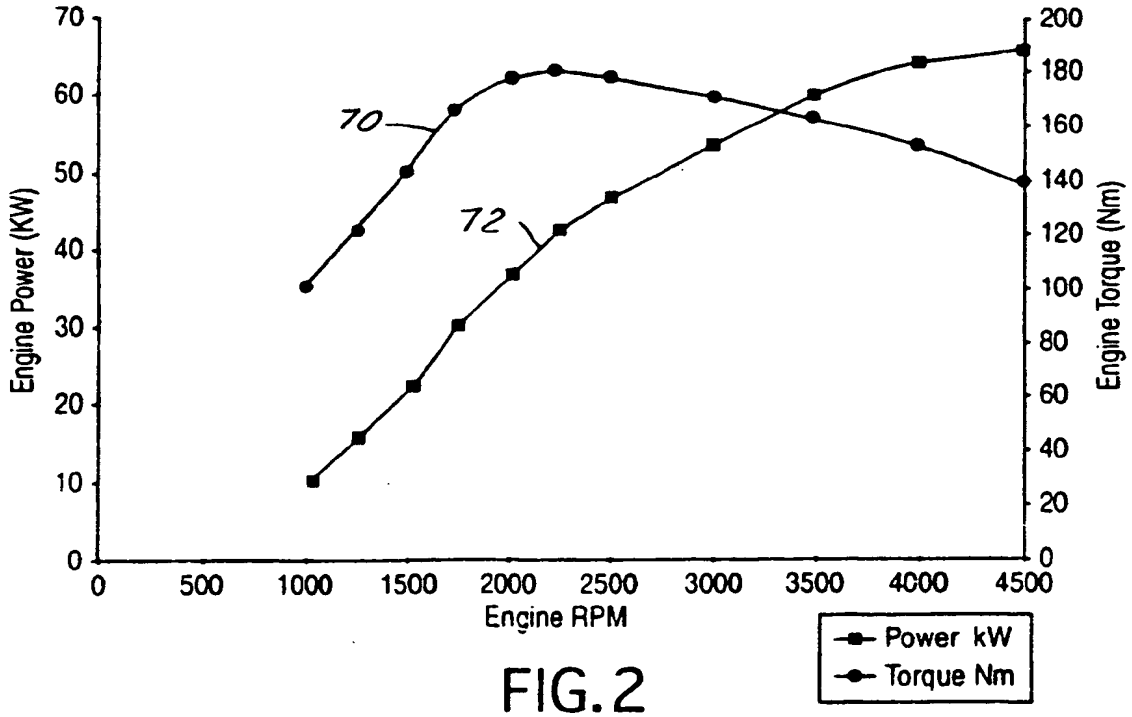
Engine Power (KW)
Engine Torque (Nm)
Engine RPM
70
72
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140
160
180
200
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Power kW
Torque Nm

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 31 0669

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 818 116 A (IBARAKI RYUJI ET AL) 6 October 1998 (1998-10-06) * column 1, line 62 - column 5, line 11; figure 1 *	1-7	F02N11/08 F02N11/04
X	EP 0 903 492 A (TOYOTA MOTOR CO LTD) 24 March 1999 (1999-03-24) * claim 1 *	1,3-7	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F02N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 March 2001	Bijn, E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 31 0669

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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15-03-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5818116 A	06-10-1998	JP 9222064 A	26-08-1997
EP 0903492 A	24-03-1999	JP 11153075 A	08-06-1999